

CLAIMS

What is claimed is:

1 1. An apparatus, comprising:

2 a first region of an optical waveguide disposed in semiconductor material, the first
3 region having a first conductivity type;

4 a second region of the optical waveguide disposed in the semiconductor material, the
5 second region having a second conductivity type opposite to the first conductivity type;

6 a first contact coupled to the optical waveguide at a first location outside an optical
7 path of an optical beam to be directed through the optical waveguide;

8 a first buffer of insulating material disposed along the optical waveguide between the
9 first contact and the optical path of the optical beam; and

10 a buffer plug of insulating material disposed in the optical waveguide on a same side
11 as the first location, the buffer plug to help direct a mode of the optical beam away from the
12 first location.

1 2. The apparatus of claim 1 wherein the first region of the optical waveguide
2 includes a first higher doped region coupled to the first contact at the first location to improve
3 an electrical coupling between the first contact and the optical waveguide, the buffer plug to
4 further help direct the mode of the optical beam away from the first higher doped region.

1 3. The apparatus of claim 1 further comprising:

2 a second contact coupled to the optical waveguide at a second location outside the
3 optical path of the optical beam, the buffer plug to further help direct the mode of the optical
4 beam away from the second location; and

5 a second buffer of insulating material disposed along the optical waveguide between
6 the second contact and the optical path of the optical beam.

1 4. The apparatus of claim 3 wherein the first region of the optical waveguide
2 includes a second higher doped region coupled to the second contact at the second location to
3 improve an electrical coupling between the second contact and the optical waveguide, the
4 buffer plug to further help direct the mode of the optical beam away from the second higher
5 doped region.

1 5. The apparatus of claim 3 wherein the first and second buffers of insulating
2 material are laterally disposed along sidewalls of the optical waveguide to serve as cladding
3 so as to help confine the optical beam within the optical waveguide.

1 6. The apparatus of claim 5 wherein the first and second buffers of insulating
2 material are adapted to serve as electrical isolators to isolate first and second contacts from
3 the optical path of the optical beams.

1 7. The apparatus of claim 1 wherein the optical waveguide comprises a rib
2 waveguide, wherein the first region comprises a rib portion of the optical waveguide and the
3 second region comprises a slab portion of the optical waveguide.

1 8. The apparatus of claim 1 wherein the optical waveguide comprises a strip
2 waveguide.

1 9. The apparatus of claim 1 further comprising a third contact coupled to the
2 second region of the optical waveguide at a third location outside the optical path of the
3 optical waveguide, wherein the first buffer of insulating material is disposed between the
4 third contact and the optical path of the optical beam.

1 10. The apparatus of claim 3 further comprising a fourth contact coupled to the
2 second region of the optical waveguide at a fourth location outside the optical path of the
3 optical waveguide, wherein the second buffer of insulating material is disposed between the
4 fourth contact and the optical path of the optical beam.

1 11. The apparatus of claim 1 wherein a charge concentration in the optical
2 waveguide is coupled to be modulated in response to a signal coupled to be received by the
3 first contact.

1 12. The apparatus of claim 1 further comprising:
2 an insulating region disposed between the first and second regions of the optical
3 waveguide; and
4 a charge modulated region to be modulated along the optical path of the optical beam
5 and proximate to the insulating region between the first and second regions of the optical
6 waveguide, the charge modulated region to modulate a phase of the optical beam to be
7 directed through the optical waveguide.

1 13. A method, comprising:
2 directing an optical beam along an optical path through an optical waveguide
3 disposed in semiconductor material;
4 applying an electrical signal to a first contact coupled the optical waveguide at a first
5 location;
6 isolating the first contact from the optical path through which the optical beam is
7 directed with a first buffer of insulating material disposed along the optical waveguide
8 between the first contact and the optical path of the optical beam; and
9 directing the optical beam away from the first contact with a buffer plug of insulating
10 material disposed in the optical waveguide on a same side of the optical waveguide as a side
11 of the optical waveguide to which the first contact is coupled.

1 14. The method of claim 13 further comprising:
2 improving an electrical coupling between the first contact and the optical waveguide
3 with a first higher doped region of semiconductor material included in the optical waveguide
4 and coupled to the first contact; and
5 directing the optical beam away from the first higher doped region of semiconductor
6 material with the buffer plug of insulating material disposed in the optical waveguide.

1 15. The method of claim 13 further comprising:
2 applying the electrical signal to a second contact coupled the optical waveguide at a
3 second location; and

4 isolating the second contact from the optical path through which the optical beam is
5 directed with a second buffer of insulating material disposed along the optical waveguide
6 between the second contact and the optical path of the optical beam.

1 16. The method of claim 15 further comprising:
2 improving an electrical coupling between the second contact and the optical
3 waveguide with a second higher doped region of semiconductor material included in the
4 optical waveguide and coupled to the second first contact; and
5 directing the optical beam away from the second higher doped region of
6 semiconductor material with the buffer plug of insulating material disposed in the optical
7 waveguide.

1 17. The method of claim 13 further comprising modulating in response to the
2 electrical signal a charge concentration along the optical path through the optical waveguide
3 through which the optical beam is directed to phase shift the optical beam in response to the
4 electrical signal.

1 18. A system, comprising:
2 an optical transmitter to generate an optical beam;
3 an optical receiver optically coupled to receive the optical beam;
4 an optical device optically coupled between the optical transmitter and the optical
5 receiver, the optical device including an optical phase shifter to modulate a phase of the
6 optical beam, the optical phase shifter including:

7 a first region of an optical waveguide disposed in semiconductor material, the
8 first region having a first conductivity type;

9 a second region of the optical waveguide disposed in the semiconductor
10 material, the first region having a second conductivity type opposite to the first
11 conductivity type;

12 a first contact coupled to the optical waveguide at a first location outside an
13 optical path of an optical beam to be directed through the optical waveguide;

14 a first buffer of insulating material disposed along the optical waveguide
15 between the first contact and the optical path of the optical beam;

16 a buffer plug of insulating material disposed in the optical waveguide on a
17 same side as the first location, the buffer plug to help direct a mode of the optical
18 beam away from the first location.

1 19. The system of claim 18 wherein the first region of the optical waveguide
2 includes a first higher doped region coupled to the first contact at the first location to improve
3 an electrical coupling between the first contact and the optical waveguide, the buffer plug to
4 further help direct the mode of the optical beam away from the first higher doped region.

1 20. The system of claim 18 wherein the optical devices further comprises:
2 a second contact coupled to the optical waveguide at a second location outside the
3 optical path of the optical beam, the buffer plug to further help direct the mode of the optical
4 beam away from the second location; and
5 a second buffer of insulating material disposed along the optical waveguide between
6 the second contact and the optical path of the optical beam.

1 21. The system of claim 20 wherein the first region of the optical waveguide
2 includes a second higher doped region coupled to the second contact at the second location to
3 improve an electrical coupling between the second contact and the optical waveguide, the
4 buffer plug to further help direct the mode of the optical beam away from the second higher
5 doped region.

1 22. The system of claim 18 wherein the a charge concentration in the
2 semiconductor material along the optical path of the optical waveguide of the phase shifter is
3 adapted to be modulated in response to a signal coupled to be received by the first contract to
4 modulate a phase of the optical beam to be directed through the optical waveguide.

1 23. The system of claim 18 wherein the optical phase shifter is included in an
2 optical modulator to selectively modulate the optical beam.

1 24. The system of claim 18 wherein the optical phase shifter is included in an
2 optical switch to selectively switch the optical beam from an input of the optical switch to
3 one of a plurality of outputs of the optical switch.

1 25. An apparatus, comprising:
2 an optical splitter disposed in semiconductor material, the optical splitter to split an
3 optical beam to be directed through the optical splitter into a plurality of portions of the
4 optical beam; and

5 a plurality of optical phase shifters disposed in the semiconductor material, each of
6 the plurality of optical phase shifters optically coupled the optical splitter to receive a
7 respective one of the plurality of portions of the optical beam, the plurality of optical phase
8 shifters adapted to adjust relative phase differences between the plurality of portions of the
9 optical beams to control an interference resulting from the plurality of portions of the optical
10 beams when recombined, each of the plurality of optical phase shifters including:

11 a first region of an optical waveguide disposed in the semiconductor material,
12 the first region having a first conductivity type;

13 a second region of the optical waveguide disposed in the semiconductor
14 material, the second region having a second conductivity type opposite to the first
15 conductivity type;

16 a first contact coupled to the optical waveguide at a first location outside an
17 optical path of a respective portion of the optical beam to be directed through the
18 optical waveguide;

19 a first buffer of insulating material disposed along the optical waveguide
20 between the first contact and the optical path of the respective portion of the optical
21 beam; and

22 a buffer plug of insulating material disposed in the optical waveguide on a
23 same side as the first location, the buffer plug to help direct a mode of the respective
24 portion of the optical beam away from the first location.

1 26. The apparatus of claim 25 wherein the first region of the optical waveguide
2 includes a first higher doped region coupled to the first contact at the first location to improve
3 an electrical coupling between the first contact and the optical waveguide, the buffer plug to

4 further help direct the mode of the respective portion of the optical beam away from the first
5 higher doped region.

1 27. The apparatus of claim 25 further comprising:
2 a second contact coupled to the optical waveguide at a second location outside the
3 optical path of the respective portion of the optical beam, the buffer plug to further help direct
4 the mode of the respective portion of the optical beam away from the second location; and
5 a second buffer of insulating material disposed along the optical waveguide between
6 the second contact and the optical path of the respective portion of the optical beam.

1 28. The apparatus of claim 27 wherein the first region of the optical waveguide
2 includes a second higher doped region coupled to the second contact at the second location to
3 improve an electrical coupling between the second contact and the optical waveguide, the
4 buffer plug to further help direct the mode of the respective portion of the optical beam away
5 from the second higher doped region.

1 29. The apparatus of claim 25 wherein the apparatus is an optical switch adapted
2 to control the interference resulting from the plurality of portions of the optical beams when
3 recombined to selectively switch the optical beam to be received by one of a plurality of
4 optical receivers in response to a signal received by at least one of the plurality of optical
5 phase shifters.

1 30. The apparatus of claim 25 wherein the apparatus is an optical modulator
2 adapted to control the interference resulting from the plurality of portions of the optical

- 3 beams when recombined to modulate the optical beam in response to a signal received by at
- 4 least one of the plurality of optical phase shifters.